Merits of a 40GbE serial solution for the 40GbE 10km SMF PMD objective

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Introduction

• 40GbE over 10km of SMF was adopted as an Objective to address servers, datacenters and access interconnection (*barbieri_01_0308*, *simsarian_01_0308*)

• In the past two options have been discussed

  Serial (*jewell_03_0508*)

  CWDM 4x10G (*cole_03_0508*)

• Both options are technically feasible (*cole_04_0708*)

• Cost is the critical deciding factor in the selection process
Agenda

• This presentation presents the merits of 40GbE serial in terms of;
  • cost
  • power consumption
  • availability
  • form factor evolution
### Higher Volume for 40GE 10km SMF

From “carter_40_01_0208.pdf”

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>10GE Total</strong></td>
<td>1600K</td>
<td>1800K</td>
<td>2500K</td>
</tr>
<tr>
<td><strong>40/10 ratio</strong></td>
<td>15%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td><strong>40GE Total</strong></td>
<td>240K</td>
<td>360K</td>
<td>500K</td>
</tr>
<tr>
<td><strong>40GE LR %</strong></td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td><strong>40GE 10km</strong></td>
<td>120K</td>
<td>180K</td>
<td>250K</td>
</tr>
</tbody>
</table>

**Note1:** LightCounting estimation for 2010 & 2011. Yr 2012 is estimate.

**Note2:** Estimated from carter_40_01_0208.pdf (40GbE SMF Ad-hoc)

**Note3:** Ratio on distance is referred to “goergen_01_1107”, where around 50% for 10km category is reported.

40GbE is estimated to be 15% of the volume of 10GbE.
Economic Feasibility

- The consensus generally and amongst CWDM advocates is that serial will be cost effective in long term.

- Recent survey among many optical and electronic component vendors suggests the serial will be MORE cost competitive than CWDM in mid 2010.

- LX4 is NOT cost effective comparing to 10GBASE-LR, 10GBASE-SR and 10GBASE-LRM.

- CWDM will require significant investment in optical packaging. High Speed IC technology is amortized across all IC applications.
Main Drivers to Drop Serial Cost in 2010

(From “traverso_04_0308.pdf”)

- Optics packaging
- 4:1 Serdes instead of 16:1 Serdes
- Low cost SerDes packaging
- Low cost RF interconnect
  - Substrate interconnection via micro-stripline or stripline
- High volume
Cost analysis versus 10GbE-LR for both 40G 10km CWDM & Serial

Serial provides a more cost-effective solution than CWDM after yr2010.

Estimated values are ratio referred to 10GE LR for each component respectively.

Relative Cost Comparison

<table>
<thead>
<tr>
<th>Component</th>
<th>10GE LR</th>
<th>Serial w/o GPPO</th>
<th>CWDM</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOSA/ROSA w/O-Mux,Demux</td>
<td>1.0</td>
<td>5.9 4.4 3.4</td>
<td>8.4 7.5 6.8</td>
</tr>
<tr>
<td>CDR/SerDes</td>
<td>1.0</td>
<td>7.5 5.0 4.0</td>
<td>4.0 3.6 3.2</td>
</tr>
<tr>
<td>Other component</td>
<td>1.0</td>
<td>1.8 1.8 1.8</td>
<td>1.7 1.7 1.7</td>
</tr>
<tr>
<td>TEST</td>
<td>1.0</td>
<td>2.0 1.8 1.6</td>
<td>4.0 3.6 3.2</td>
</tr>
<tr>
<td>Total</td>
<td>1.0</td>
<td>4.6 3.5 2.9</td>
<td>5.9 5.3 4.9</td>
</tr>
</tbody>
</table>
RF Interconnection Methods

Current OC768

FPC interconnection

GPPO edge mount connectors

(*1) TOSA(w/ driver)+ROSA cost, not include volume effect
From traverso_01_0909
Edge Mount GPPO Method

Transmission loss = 1.0dB@40GHz
f_{3dB} bandwidth = 60GHz

Available today
FPC Interconnection Method

FPC film (10mm, R=0.75, 90deg bend)

Ceramic feed-through

GPPO connector  Driver IC integrated EML module

(*OECC 2008, WeC-1)

Available 2009

Input waveform

Bit rate : 39.8Gb/s
Data pattern : PRBS31

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>X-point</td>
<td>50.1 %</td>
</tr>
<tr>
<td>Jitter p-p</td>
<td>4.01 ps</td>
</tr>
<tr>
<td>Jitter rms</td>
<td>0.64 ps</td>
</tr>
<tr>
<td>Eye amp.</td>
<td>1.2 V</td>
</tr>
<tr>
<td>Tr</td>
<td>7.11 ps</td>
</tr>
<tr>
<td>Tt</td>
<td>7.44 ps</td>
</tr>
</tbody>
</table>

1. Alumina board connection (Reference)

2. FPC film connection

Available 2009

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Cost projection from technical point

From technology point of view, drastic cost reduction, usually observed in initial development stage, is achievable.
Cost projection driven by volume

- A reasonable historical reference point is that of OC192 (2 km) and 10GbE LR

- Within two years of the adoption of the 10GbE LR standard, OC192 costs had dropped ~6X

- Under a similar scenario, 40GE serial solution will be more cost effective than CWDM in mid 2010
This “cost” analysis compares a 40Gbit/s 1550nm EML with a 40Gbit/s 1310nm EML – and treats the two wavelengths the same. This is not accurate! Treating the two lambdas as equal is PESSIMISTIC!

Notes:
- Ovum Historical cost data used
- Lighcounting (LC) historical cost data used
- 10G costs relative to yr 2000 OC192
- 40G costs relative to yr 2005
This “cost” analysis compares a 40Gbit/s 1550nm EML with a 40Gbit/s 1310nm EML – and treats the two wavelengths the same. This is not accurate! Treating the two lambdas as equal is PESSIMISTIC!

Notes:
- Ovum Historical cost data used
- Lighcounting (LC) historical cost data used
- Costs are actual
- Horizontal lines are powers of 10

Place trend line over 40G curve – predicted cost reduction is not unprecedented...

Draw Trend line approximating cost reduction
## Power Comparison -- Serial vs. CWDM

*From “jewell_03_0508.pdf”*

<table>
<thead>
<tr>
<th>40G 10km Serial</th>
<th>Y2009 Power (W)</th>
<th>Y2011 Power (W)</th>
<th>40G 10km CWDM</th>
<th>Y2009* Power (W)</th>
<th>Y2011** Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EML TOSA</td>
<td>1.5</td>
<td>1.0</td>
<td>DML TOSA/Mux</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Laser Bias</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEC +</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EML Driver</td>
<td>0.8</td>
<td>0.6</td>
<td>4X DML Driver</td>
<td>2.1</td>
<td>1.7</td>
</tr>
<tr>
<td>4:1 / 1:4</td>
<td></td>
<td></td>
<td>XFI CDR</td>
<td>1.8</td>
<td>1.0</td>
</tr>
<tr>
<td>MUX/DMUX/CDR</td>
<td>2.0†</td>
<td>1.5††</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PIN/TIA</td>
<td>0.4</td>
<td>0.3</td>
<td>4XPIN/TIA ROSA</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Other</td>
<td>0.1</td>
<td>0.1</td>
<td></td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Total Power</td>
<td>4.8</td>
<td>3.5</td>
<td>5.0</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Ratio to CWDM</td>
<td>0.96</td>
<td>0.97</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

* Intermediate between “Now” and “2010” values from Tsumura’s presentation to the 40GbE SMF Ad-hoc
** Slightly reduced from the “2010” values from Tsumura - 40GbE SMF Ad-hoc
† SiGe
†† CMOS
YR2009 1x40G SerDes Power Summary

\[ 0.65 + 0.15 + 0.30 + 0.90 = 2.0 \text{ Watts} \]
Form Factor Evolution

Serial

Double XENPAK

Serial is the only solution which offers the prospect of implementation in QSFP

CWDM

Double XENPAK

2009-2010

2011-2012

20??

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Summary

• Recommend the 802.3ba task force to adopt 40GbE Serial PMD for 10Km SMF:
  • Is the only viable long term solution
  • It is the only solution that could potentially be implemented in the QSFP form factor
  • Technical feasibility
    • Packaging technology – Available today
    • Process technology – Available today
    • Power consumption – Lower than CWDM
  • Economic feasibility
    • Lower cost than CWDM when volume ramps (mid 2010)
    • Serial PMD cost reduction follows silicon cost reduction path
  • Accelerates the deployment of high volume 40Gb Ethernet
  • Eliminates standardization of two PMDs